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OCEAN WAVE FORECASTING.(U)

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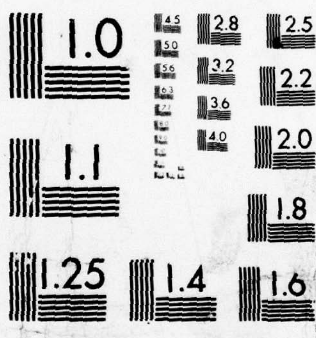

MICROCOPY RESOLUTION TEST CHART
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ABSTRACT

Title: Ocean Wave Forecasting.

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The purpose of this research was to develop a general numerical program for integrating the Boltzman integral representing the third-order nonlinear energy transfer in a surface-wave spectrum. As described in the research proposal, a detailed study of the nonlinear energy transfer is an essential first step for developing realistic numerical wave-prediction models, since it has been established in a number of recent field experiments that the nonlinear transfer has a strong influence on the shape and evolution of a growing wind-sea spectrum. Existing integration programs are computationally expensive and not sufficiently general to treat an arbitrary wave spectrum with frequency dependent, asymmetric directional spreading functions. The purpose of the research was therefore to develop a more efficient, general integration method which could be used for extensive numerical experiments.

ABSTRACT

The first step was to investigate the possibility of computing the integral using new coordinates which exploit the symmetry of the interaction coefficients and the resonance condition (detailed-balance conditions). The theory was recast in these coordinates and turned out to be in several respects simpler for computational purposes than previous integration methods. In previous work, the approach had been to integrate the three-dimensional Boltzman integral for a fixed resultant wavenumber, in accordance with the integral form of the transfer rate presented in the original theoretical papers. Subsequently, the two-dimensional resultant wavenumber was varied, and the integration repeated for the new wavenumber, and so on, until the entire two-dimensional spectral transfer function was computed. In the present approach, the collision integral was integrated with respect to a symmetrized set of coordinates in a five-dimensional phase space, each collision producing an incremental change in the spectrum at the four interacting wavenumbers. According to the principal of detailed balance, the incremental change is the same (to within a sign) for each of the interacting wavenumbers. The set of interacting wavenumbers is different for each new set of collision parameters. The final change of the spectrum per unit time interval from all collisions is obtained by

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collecting the incremental spectral changes per collision in a discretised set of wavenumber bins. The new integration technique has the advantage of automatically conserving energy, momentum and action, and avoids the previous repetitive summations over the same interaction combination with permuted wavenumbers.

A second important innovation was the separation of the calculation of the interaction cross sections and the actual integration in two independent routines. By reading in the results of the cross-section calculation for the integration calculation it was possible to reduce the integration - in repeated applications - to a fraction of the previous computation time.

One disadvantage of the technique is that it differs so completely from the previous computational methods used by Hasselmann, Sell, Cartwright, and Webb, that a check on the rather complicated coding is possible only through the agreement of the final results with previous calculations. However, these tests now appear satisfactory, and the program is ready for application (see follow-up research proposal for 1979).

A complication which was not foreseen and which required some modification to the original program arose through an integrable singularity at the center point of the interaction phase space (the point at which all interacting wavenumbers become equal). The singularity is associated with a stationary point in the δ-function representing the frequency resonance condition. It had been recognised before but is cancelled by a zero in another factor of the integrand containing the spectral products of the interacting wavenumbers. Thus in the first version of the program the singularity was simply ignored. However, for very sharply peaked spectra - which are typical of wind seas or swell - the zero associated with the spectral products is very sharp; the spectral-product terms can therefore take quite large values very close to the central interaction point. Consequently, the large values of the frequency δ-function near the central interaction point are not cancelled by the spectral product term in the immediate vicinity of the central interaction point. In fact, it was found that the main contributions to the nonlinear transfer rate arise from interactions in this rather limited region of phase space. The

problem was remedied by stretching all integration coordinates in the neighborhood of the central interaction point.

In summary, the integration program was successfully developed at a total cost of approximately one man-year (plus independent support from the principal investigator and computer facilities), but turned out to be rather more complex numerically and mathematically than originally (perhaps rather optimistically) envisaged by the principal investigator. It was hoped that the program could actually be applied already in the first period of the proposal to a series of nonlinear computations, but this will have to be deferred until the next grant period.

Hamburg, December 12, 1978

(Prof. Klaus Hasselmann)